DOCUMENT RESUME

ED 444 843 SE 063 918

AUTHOR Haidar, Abdullateef H.; Balfakih, Nagib M.
TITLE United Arab Emirates Science Students' Views about the Epistemology of Science.
PUB DATE 1999-00-00
NOTE 35p.; Paper presented at the Annual Meeting of the National Association for Research in Science Teaching (Boston, MA, March 28-31, 1999). Page 10 of the document is cropped.
PUB TYPE Reports - Research (143) -- Speeches/Meeting Papers (150)
EDRS PRICE MF01/PC02 Plus Postage.
DESCRIPTORS Biology; Chemistry; Constructivism (Learning); *Cultural Influences; *Epistemology; Foreign Countries; Geology; High Schools; *Instructional Materials; Mathematics; Physics; Science Education; Scientific Methodology; *Student Attitudes
IDENTIFIERS *United Arab Emirates

ABSTRACT

This study investigated United Arab Emirates (UAE) high school students' views about the epistemology of science. About 1,600 high school science students, from the seven Emirates that constitute the UAE, participated in the study during the 1997-98 school year. Students responded to a questionnaire composed of 15 items selected mainly from the epistemology component (nature of scientific knowledge) of the Views On Science-Technology-Society (VOSTS). Only the stems of the items were selected from the VOSTS; the multiple-choice responses were developed according to the original procedure outlined by the original authors (Aikenhead and Ryan, 1992). Results indicated that Emirates high school science students held mixed understandings about the epistemology of science. About 21-68 percent of students' responses were classified as religious understanding about the nature of science; 9-70 percent of students' responses were classified as traditional understanding of science; and 3-59 percent of students' responses were classified as constructivist understanding of science. The results suggested that students' cultural background influence their views about the epistemology of science. People involved in science teaching in the United Arab Emirates should consider students' cultural background when developing and presenting science curriculum materials. (Contains 60 references.) (YDS)

Running head: EMIRATES STUDENTS' EPISTEMOLOGY OF SCIENCE

United Arab Emirates Science Students' Views about the Epistemology of Science

Abdullateef H. Haidar
Al-Ain Box 17551
a.haidar@uaeu.au.ae

&

Nagib M. Balfakih
Fujairah Box 1854
nagib@emiraters.net.ae

United Arab Emirates University

United Arab Emirates

United Arab Emirates Science Students' Views

about the Epistemology of Science

Students' views about the nature of science have been the topic of study by many researchers (BouJaoude, 1996; Cleminson, 1990; Duschl, 1990; Pomeroy, 1993; and Rayan & Aikenhead, 1992). Science educators agree that learning science involves other aspects of science like process/method and the nature of science (Lederman & Niess, 1997; Millar, 1995). During the 50's and the 60's, when positivism was dominating the philosophy of science, school science was heavily embedded with that perspective. As a result science textbooks were prepared to include heavy content knowledge and neglected both the processes and the nature of science. Ignorance of the present understanding of the nature of science (contemporary viewpoint) might have prevented students from opportunities to discuss issues related to their daily lives and it may have led students to adopt what we have called the uninformed view about science that is largely consistent with the positivist position towards science. Emphasizing this traditional view of science can create conflict between students' religious and scientific beliefs (Haidar, 1999). The traditional view stresses certain beliefs such as: science is merely a means of understanding a clock work-universe; the only way of gaining scientific knowledge is through the application of the scientific method; scientists are not influenced by their background; and scientific knowledge is absolute and devoid of creativity and imagination (Butterfield, 1965; Keller, 1985; Popper, 1962, 1968). On the other hand, the contemporary view of the epistemology of science does not. The contemporary view of science stresses that science is a set of socially negotiated understandings of the universe. There are other ways to gain knowledge not only the scientific method. Scientists are influenced by their cultural backgrounds, and scientific knowledge is tentative (Kuhn, 1970; Tobin and Tippins, 1994).

about topics to include in the science curriculum. However, they almost all would include the nature of science in science curriculum (American Association for the Advancement of Science, 1989; Hazen & Trefil, 1991; Lederman, 1992; and Rutherford & Ahlgren, 1990).

In the UAE, schools follow the national curriculum. Science is introduced as a general science course starting at the first grade. Starting from the 11th grade, a student has to select between one of two tracks: science or art. Science students who are the subject of the present study take mathematics, chemistry, physics, biology, and geology over two years as well as other common subjects. Although there appears to be a strong desire in the UAE to improve science teaching, one important objective that has not been stated clearly in the teaching of science is the understanding of the nature of science. It is extremely important for science teaching to provide students with a scientific environment that helps them understand the scientific enterprise. Science students should have a clear understanding and implications for words such as facts, concepts, hypothesis, theory, law, and assumption; they should know how scientists achieve their discoveries.

Since the nature of science is not stated clearly among the goals of science teaching in the UAE, how did Emirates high school students view the epistemology of science? Science reform designers in the UAE need evidence to see weaknesses and strengths of the present curriculum. This study offers science teachers better understanding of their students' background and their personal influence on students' formation of knowledge. Finally, it offers science educators around the world evidence of the influence of culture on students' epistemology of science.

Purpose of the study

The purpose of the study was to investigate UAE high school students' views about the epistemology of science. More specifically, the study aimed at identifying and analyzing Emirates high school science students' views about the epistemology of science.

Methodology

Subjects

About sixteen hundred high school students participated in the study. They included 11th and 12th grade science track students. Their classes were selected randomly from 22 schools (11 boys' schools and 11 girls' schools) from all seven Emirates that constitute the UAE. A students' average age was about 17.5 years. The questionnaire was distributed nationwide; the sample represented 10% of the students in the UAE. Data collection covered both urban and rural areas of the UAE and included citizens and non-citizens[1] studying during the academic year 1997/1998.

Questionnaire

During the 1960s and the 1970s, a number of questionnaires were developed to assess students' understanding of the nature of science. The format of questionnaires varied from multiple choice, such as TOUS (Klopfer & Cooley, 1961), NOSS (Kimball, 1965), and NOSK (Rubba & Anderson, 1978), to open-ended questionnaires (Griffiths & Barman, 1995). Multiple choice questionnaires have been criticized for their lack of validity (Aikenhead, 1988).

There are two main factors that influence the assessment of students' understandings of the nature of science. First, the nature of science is very complex;

[1] The UAE government offers free education for its citizens as well as non-national employees'

this makes it difficult to be captured by a small number of choices proposed by researchers to cover the factors which may affect the students' view of the nature of science. There are many factors that contribute to science students' knowledge construction, such as society, family, culture, religion, media, folk stories, etc.

Secondly, the influence of students' backgrounds may differ from the researchers who develop questionnaires; it is difficult for researchers to comprehend students' views. As a result, multiple-choice questionnaires, which assess students' view of the nature of science, become weak instruments. Munby (1982) added that there is likelihood that students interpret written items in ways different from what was intended by the researcher.

Interviews can better serve as assessment of students' understandings of the nature of science. They give students a better chance to elaborate on their views and provide researchers with deeper interpretation for the responses (Griffiths & Barman, 1995). However the interview technique is not feasible for the large number of students in this study because the population of this research is the whole 11^{th} and 12^{th} grade science students in the UAE. As a result, the technique of Aikenhead and Ryan (1992) was adopted to avoid the shortcomings of the closed questions and the difficulties of the interviews.

To develop the questionnaire for this study, 21 items were selected from the epistemology component (nature of scientific knowledge) of the Views On Science-Technology-Society (VOSTS) questionnaire developed by Aikenhead & Ryan (1992). Only the stems of the items were kept from the original questionnaire. The multiple-choice answers (students' responses) were developed according to the original procedure outlined in Aikenhead and Ryan (1992); the original authors of the VOSTS suggested that item stems are distributed to about 50-60 students; their

responses then can be edited to constitute the multiple choices. Development of the multiple choices was necessary to include students' views (that reflect their culture) instead of forcing students to select views that were originally articulated by Canadian students.

A sample of 60 male and female students from the 11th and 12th grade science track was selected randomly to produce the multiple choices. The students answered 21 open-ended questions about the epistemology of science. The questionnaire assesses students' views about the following topics: definition of science, nature of scientific observation, nature of scientific models, nature of classification schemes, tentativeness of scientific knowledge, hypotheses theories and laws, role of scientific assumptions, scientific equations and nature, the scientific method, scientific approach to investigations, precision and uncertainty in scientific knowledge, epistemological status of scientific knowledge, and paradigms vs. coherence of concepts across disciplines. Students' responses were edited and classified into groups according to similarities. These groupings become the multiple choices. Six items were deleted because students complained that the questionnaire was too long and that some items had similar purposes. The number of offered choices varied between 6 to 9. Three more choices were added at the end of every item. They are: I don't understand, I don't know enough about this subject to make a choice; and none of these choices fits my basic viewpoint. These were suggested by the original authors to represent any other possible responses. In the final stage, fifteen items with multiple-choice format constituted the final version of the questionnaire.

Data analysis

Frequency counts and percentages were calculated for each position within each item. Moreover, students' views were categorized mainly into uninformed and informed groups. The term "uninformed views" is used in this study to represent

views close to the traditional Baconian views of science. The term "informed views" is used in this study to represent views close to the accepted views that have emerged from recent work in physics and history and philosophy of science. Since the percentages of students who selected the last three choices in each item ranged mostly between 2 and 6, they were neglected both in the results and discussion section below because of their minuteness.

Results and Discussion

Definition of Science

During the 1950's, the focus of science teaching was on the content of science (Cleminson, 1990; and Hurd, 1960). As a continuation of this, the focus during the 1960's and 1970's proceeded to include also the processes of science (Cleminson, 1990; and Wlech, 1979). Recently the focus of science teaching has also included the social context of science (American Association of the Advancement of Science, 1990). In the UAE, the focus is still on content and some calls to incorporate processes. Given this, what were Emirates students' understandings about the definition of science?

In item 1 (10112)[2], students were asked to select one of several views about the definition of science. The results are summarized in Table (1). Students' responses were classified in three groups. Group one included 49% who agreed with the view of science from an uniformed standpoint; 28% content (positions B and C), 7% processes (positions E and F), and 14% content and processes (position D). Group two included 15% of the sample who selected position A that is consistent with the informed view; they viewed science as a tool for social purpose-the benefit of humankind. Group three included 34% of the sample who selected position G; these students misunderstood the question. They mixed natural science and religious

[2] The numbers in parentheses represent the numbers of the items in the original questionnaire

knowledge. Science in English means a human activity that results in a new knowledge within a social context. On the other hand, the Arabic word that is frequently used to represent science is *ilm*. The meaning of this word is not necessary what it means in English. *Ilm* has a broad meaning; *ilm* is used in every day life to refer to the body of knowledge of everything in the universe, known or even not known yet (in present and in the future). In the Islamic culture, human knowledge, *ilm*, is considered less than a drop in an ocean. Only God - the Great Knower- knows everything. This might have given students different interpretations of the nature of science that was reflected on their views of the epistemology of science as argued by Aikenhead and Ryan (1992).

[Please insert Table (1) about here]

These results differ from those found by Griffiths and Barman (1995) who interviewed students from three countries, Canada, USA, and Australia. Western students displayed environmental and everyday worldviews, while Emirates students displayed an uniformed view. Also when Aikenhead and Ryan (1992) reported their findings for the same question; they showed that students' views were divided between content and process and ignored the social aspect of science. Comparing the results of these studies with the results of the present study, it can be said that the uninformed view about science is present in all of these cultures. However, Emirates students' misunderstanding of the question has shown the deep influence of their culture on their view.

Nature of Scientific Observations

Observation is a key element in the processes of science. Science curriculum designers emphasize its importance. The traditional (uninformed) view about observation emphasizes that scientists should be objective; and observation is theory-free, i.e., the observer should detach him/herself from the observed in order

to be honest and to report data accurately and bring reliable results. On the other hand, the contemporary (informed) view stresses that observation is "naive" and should be removed from the mind of students. It is argued that the observer is part of the observed; he or she observes through lenses made of theories he or she believes in (Cleminson, 1990; Abimbola, 1983), or what others called paradigms (Kuhn, 1962), presuppositions (Brown, 1977), or research programs (Lakatos, 1970). For example, Hanson (1958) indicated that what we see is determined by what we know; also Kuhn (1970) was skeptical of scientists' efforts to produce any neutral scientific language. The contemporary view recognizes dream, intuition, play, and great inexplicable leaps as potentially part of the scientific endeavor. For scientists to be objective and to make meaningful observation, they should be attached to the object of inquiry (Keller, 1983; Rattansi, 1989; Pomeroy, 1992). But how did Emirates high school students view observation?

Students' views about scientific observation were assessed by item 2 (90111). Students were asked to respond to the following statement: "Scientific observations made by competent scientists will usually be different if the scientists believe different theories." Students' responses were categorized in two groups. Group one included 9% of the sample; it is represented by students' selections of positions that were consistent with the uninformed view about the nature of science. Students believed that qualified scientists should not be influenced by their personal conviction and should report only what they see. Group two was the largest; it contained 86% of the students. They thought that scientists make different observations on the same thing, a choice consistent with the informed view. Students' reasons were divided into four sub-groups. In sub-group one, 9% of the sample related the different observations to the different approaches scientists use when conducting their research. In sub-group two, 24% of the sample attributed the

objectives. In sub-group three, 27% of the sample attributed the different observations to the personality of scientists, as human beings. In subgroup four, the students' view was influenced by their culture background, of 26% of students who agreed that scientists' observations differ because God created us differently so that would be reflected on observing things. These results differ from previous results reported by BouJaoude (1996) who found that the majority of high school students agreed with the uninformed view about observation.

Nature of Scientific Models

Scientists use models to make their theories and ideas as close as possible to reality. Models represent things that cannot be seen and cannot be perceived directly. But how did Emirates students' see models? Item 3 (90211) assessed students' views about the following statement: "Many scientific models used in research laboratories (such as the model of heat, or the model of atom) are copies of reality." The results indicated that students' responses were categorized into three groups. Group one included 21% of the students; these students held an uninformed view about models. They thought that scientific models are a true representation of reality. Most of these students held a conception that scientists have come up with models after long and extensive experiments - models have been seen. Group two included 59% of students' responses; they agreed with the informed view that scientific models are scientists' best efforts to explain reality - not reality itself. Group two has 46% of the sample whose their view was colored by the UAE culture. They indicated that models are what scientists are able to see of reality but the real thing is in God's *ilm* (knowledge). This is consistent with the Islamic understanding that absolute knowledge is God's knowledge, but humans should strive to gain more knowledge of the universe as well as of themselves. Group three included 17% of the sample; they believed that part of the models is real and other part is not. This was

considered a misconception. Comparing present results with results from Canada (Aikenhead and Ryan, 1992) and Lebanon (BouJaoude, 1996); it could be said that a larger percentage of the UAE students hold the informed view of science.

Nature of Classification Schemes

Scientists make classification schemes to organize their knowledge and minimize unnecessary information; they strive to make their classification schemes as close as possible. There might be more than one classification scheme for the same objects or events. But how did Emirates students' see classification schemes? Students' views about classification schemes were assessed by item 4 (90311). Students were asked to determine their views about the following statement: "When scientists classify something (for example, a plant according to its species, an element according to the periodic table, energy according to its sources, or a star according to its size), scientists are classifying nature according to the way nature really is; any other way would simply be wrong." Results of students' responses fell into two groups. Group one included 16% of the sample. Their views agreed with the uninformed view, which stresses that classification schemes match the way nature really is. Group two included 80% of the sample; they held a view that is consistent with the informed view. For this group of students, classification is a personal activity, which could be different from one to another and from time to time. This percentage is much higher than that of the Canadian students, reported by Aikenhead and Ryan (1992), and the Lebanese students, reported by BouJaoude (1996). The view of 25% of this group was influenced by the UAE culture. They indicated that it was difficult to classify nature because of its vastness and because nobody knows everything except God. In summary, UAE students' held higher percentages of the informed views than the Canadian and Lebanese.

Tentativeness of Scientific Knowledge

Tentativeness of scientific knowledge is a crucial concept for the Muslims' basic beliefs. In Islam, only God possesses absolute knowledge. Therefore, it was expected that the distribution of students' responses would shift, in this item, towards the religious position. Students' views about tentativeness of scientific knowledge were assessed by item 5 (90411). They responded to the following statement: "Even when scientific investigations are done correctly, the knowledge that scientists discover from these investigations may change in the future."

[Please insert Table (2) about here]

The results were summarized in Table (2). They showed that students' responses were classified into two groups. Group one included positions A, B, and C; which were consistent with the uninformed view. These positions attracted only 6% of students' responses. Group two included students' choices of positions D, E, and F, 89%, that were consistent with the informed view. In these positions only 21% of the sample believed that scientific knowledge could change in the future. They attributed their beliefs to scientific reasons such as the role of technology and the possibility of falsification of the theories that knowledge was based on. The rest of group two (68% of the sample) attributed the tentativeness of scientific knowledge to human nature. In the UAE culture, human beings can only know very limited knowledge. The present results indicated that the majority of Emirates students subscribed to cultural views, while American students subscribed to the uninformed views as reported by Griffiths and Barman (1995) regarding the tentativeness of scientific knowledge. Present results also agreed with an earlier study (Haidar, 1999) that found that about 70% of Emirates science teachers thought that scientific knowledge is tentative.

Hypotheses, Theories, and Laws

Students' views about hypotheses, theories and laws were assessed by item 6 (90511). Students were asked to respond to the following statement: "Scientific ideas develop from hypotheses to theories, and finally, if they are good enough, to being scientific laws." Students' responses were classified into three groups. Group one included 55% of the sample; they believed that theories are developed from hypotheses and become laws when they stand firm; this is consistent with the uninformed view that argues that laws are proven theories. This percentage is close to the percentage of Canadian students reported by Aikenhead and Ryan (1992) who held this view; the study of Griffiths and Barman (1995) reported that the majority of American students believed in this simplistic hierarchical relationship. Group two included 32% of the sample who held a misunderstanding about scientific laws. Group two included two subgroups. Students in first subgroup (34% of the group) agreed that a scientific law can be discovered by accident. The rest of group two (66% of the group) did not make a distinction between laws and theories. Group three included 5% of the sample; these students indicated that both theories and laws are two different types of knowledge, which was consistent with the informed view.

Role of Scientific Assumptions

Students' views about scientific assumptions were assessed by item 7 (90521). They were asked to determine their reasoned opinions about the following statement: "When developing new theories or laws, scientists need to make certain assumptions about nature (for example, matter is made up of atoms). These assumptions must be true in order for science to progress properly." Students' responses were categorized into three groups. Group one included 29% of the sample who indicated that correct assumptions are essential for scientific progress; this is in agreement with the uninformed view. Group two included 48% of the sample; these students indicated that assumptions should not necessarily be right, which is in

agreement with the informed view. The response of 21% of group two has shown the deep influence of the culture. However, their argument was that "the law and will of God govern everything in the universe; and scientific progress has nothing to do with whether scientists' assumptions are right or wrong." Group three included 18% of students who indicated that when scientists make an assumption they do not know whether it is right or wrong! Students thought that scientists know the answer by the end of their investigations! This was classified as a misconception.

Scientific Equations and Nature

There are, mainly, two opposing views regarding the product of scientists' work. The uninformed view holds that the product of scientists' work corresponds directly to reality. The informed view holds that the product of scientists' work is scientists' best try to describe the world; scientists produce knowledge based on prior knowledge, observation, and logic. Einstein and Infeld (1938) indicated that "Physical laws try to form a picture of reality and to establish its connections with the wide world of the sense impressions". For Bronowski (1978), humans are considered one set in a connective universe. Cleminson (1990) agrees with him; he believes that it is "impossible to reduce nature to any formalizable system". Scientists' description of the product of their work should be taken within a set of theories constituting a research program, and only in an historical perspective can any experiment be considered crucial (Lakatos, 1970). But how did Emirates high school students view this topic?

Students' views about the nature of scientific equations were assessed by item 8 (90531). They were asked to identify their views about the following statement: "In reaction to Einstein's equation, $E=mc^2$, scientists said, "Such a beautifully elegant equation must be a true description of nature." This quotation shows that scientists assume their equations or ideas should match the elegance of nature." The

results of students' responses to this item were categorized into three groups. Group one included 24% of students' responses; these students believed that scientific equations were in harmony with nature, which was consistent with the uninformed view. Some of these students (6% of the sample) went further by giving a full trust in whatever scientists' say. Group two included only 19% of the sample; these students held an informed view about science. They indicated that it was not necessarily to find a harmony between scientific equations and nature. Group three was the largest; it contained 48% of the sample; they did not take clear position. They thought that a decision could be made only after theories and equations become facts; at that point we say they are in harmony, before that it is difficult to say. Their view was categorized as a misconception.

The Scientific Method

Some scientific positivists believe that the only valid way of gaining scientific knowledge is by the application of the inductive method based upon observation and controlled experimentation (Butterfield, 1965; Keller, 1985; Popper, 1962, 1968; and Whewell, 1860;); this represents the view of the traditional, Baconian, logico-empirical belief. It dominates the view of science teachers as well; Bruce King (1991) concluded, "Science teachers are predominantly scientistic and positivistic in their view of science". Popper (1963) thought the falsification of the existing theories is the best way for science progress. So, in their opinion, science does not start from facts, rather it starts from testing hypotheses, hypothetico-deductivism. On the other hand, Kuhn's (1970) scientific view is completely different from the one proposed by Popper and his predecessors. He called the beliefs, understandings, and the method used by a group of scientists working in the same line as a "paradigm". Scientific thinking or the formation of new theory occurs at the time of crisis and the abandonment of a paradigm for a new one. Contemporary philosophers of science,

scientists and science educators have been emphasizing different ways of investigation; they argue that there is no single method of investigation that is called the "scientific method". Some scientists arrive at knowledge by observing regularities of facts and then drawing a law. But what did Emirate students think about the scientific method?

Items 9 (90611) and 10 (90621) assessed Emirate students' views about the scientific method. Item 9 basically asked students to define the scientific method. Students' responses to this item were classified into two groups. Group one included seventy percent of the students; they described the scientific method uninformedly. Some of these students (28% of the sample) chose the popular sequence of the scientific method often listed in science textbooks. On the other hand, there are those students who formed group two (25% of the sample). Most of them (22% of the sample) held views influenced by the UAE culture. They believe that there were other ways of gaining knowledge, such as gospel. The rest of group two (3% of the sample) denied the existence of a sole method called the scientific method; a belief in agreement with informed views about the nature of science.

When students were asked if the use of the scientific method is the characteristic of the best scientists (item 10); they gave responses summarized in Table (3). Students' responses to this item were categorized in three groups. Group one, 48%, contained positions A, B, C, and E. Students of this group agreed with the uninformed view of science. They indicated that the only way to gain scientific knowledge is by following sequenced steps of "the scientific method". Students' selection of item F and H represented group two, 29% of the sample. Students of this group agreed with the informed view of science. About 7% believed that scientist could use any method to get valid results. The rest (22% of the sample) mentioned that God could inspire a person to gain knowledge; the scientific steps have nothing

to do with that. However, this is students' religious understanding of this topic. In Islam, this is only true for prophets – not human beings. Their view has been categorized under the informed view because they disagree with the statement and suggested other ways to gain knowledge. Group three included students who selected positions D and G, which indicated that students held a misconception about scientific knowledge. These students (18% of the sample) disagreed with the uninformed view and justified their disagreement by indicating that a scientist can reach a scientific knowledge by coincidence (The story of Newton's discovery of the gravity law is on their minds).

[Please insert Table (3) about here]

Among the 15 items that constituted the present questionnaire, students' responses to items 9 and 10 were more consistent with the uninformed view about science. This gives an indication of the strong influence of school textbooks on students' views about science. The books emphasize the uninformed view and the historical factor as discussed earlier. These results agreed with earlier results found by Haidar (1999); he found that Emirates pre-service and in-service teachers held views about the scientific method that were consistent with the uninformed view.

Progress of Scientific Knowledge

There are, mainly, two views about the progress of scientific knowledge. The first represents the uninformed view that scientific knowledge progresses by an accumulation of knowledge. The second view represents the informed view that argues that the progress of scientific knowledge is not necessarily continuous. In this regard, Kuhn (1970) distinguished between two forms of science: normal science and revolutionary science. Normal science occurs in regular circumstances as a result of knowledge accumulation; however, revolutionary science occurs as a result of

knowledge replacement, where one comprehensive viewpoint replaces another. But what did Emirate students think about progress of scientific knowledge?

Items 11 (90631) and 12 (90651) assessed students' views about the progress of scientific knowledge. Item 11 assessed students' views about accumulation of knowledge. Students were asked to identify their opinions about the following statement: "Scientific discoveries occur as a result of a series of investigations, each one building on an earlier one, and each one leading logically to the next one, until the discovery is made." The results of students' responses, to this item, were categorized into three groups. Group one included 60% of the sample. These students subscribed to the uninformed view, which emphasizes that scientific discoveries are the result of a series of investigations. Group one included 24% of the sample; their view was colored by the UAE culture. They believed that every thing has to go through a series of steps. Their argument was that God wants things to occur this way; because while God could create the universe in a second, He created the universe in six days. Group two included 22% of sample selection; they thought that discoveries could occur by accident or by trial and error, which was considered as a misconception. The third group included 14% of the sample. They held that scientific discoveries could have no relation among them but that relation might be found at a certain point and a discovery is formalized.

Item 12 assessed students' opinions about errors in scientists' work. Students were required to respond to the following statement: "Scientists should NOT make errors in their work because these errors slow the advance of science." The results indicated that students' views could be categorized into two groups. Group one included 16% of students who thought that scientists must not make any errors, which is in agreement with uninformed view of science. On the other hand, group two formed 79% of the sample. They agreed that it is natural for scientists to make

errors. In contrary to the first group; they looked at this matter positively; they thought that errors could open doors to other research ideas. Group two included 35% of the sample; they used a cultural explanation; they argued that only God is infallible. Although this view is similar to the informed view, its origin is cultural.

Precision and Uncertainty in Scientific Knowledge

Students' views about precision and uncertainty were assessed by item 13 (90711). Students were asked to respond to the following statement: "Even when making predictions based on accurate knowledge, scientists and engineers can tell us only what probably might happen. They cannot tell what will happen for certain." Students' responses to this item were classified into two groups. Group one formed only 16% of students; they indicated that scientists could make predictions to a high degree of accuracy. Group two included 78% of students' responses; they indicated that scientists cannot be 100% confident about their predictions. Group two has 38% of students who indicated that nobody knows the unknown except God; unexpected things might happen and change the expected.

Epistemological Status of Scientific Knowledge

Do scientists invent knowledge using their imagination like an artist who can create a beautiful piece of art from a stone? Or do they discover it like a gold miner who discovers gold utilizing all the effort available they have to reach their goal. The uninformed view holds the belief that knowledge is discovered; however, the informed view holds the belief that knowledge is invented. The view of free imagination of scientists to invent theory has support from historians of science such as Lakatos (1970) who stated that "the direction of science is determined primarily by human creative imagination and not by the universe of facts which surrounds us". Scientists like Einstein thought that, "Science is not just a collection of laws, a catalog of facts, it is the creation of the human mind with its freely invented laws and

concepts" (Einstein and Infeld, 1938). So what did Emirate students think about this issue?

Students' views about the epistemological status of scientific knowledge were assessed by item 14 (91013). Students responded to the following statement: "For this statement, assume that a gold miner *discovers* gold while an artist invents a sculpture. Some people think that scientists discover scientific theories. Others think that scientists *invent* them. What do you think?" Results of students' responses to this item are summarized in Table (4). The results can be categorized into two groups. Group one included 78% of students who selected positions A, D, E and F that are in agreement with the ontological view. This view argues that ideas are there all the time; the role of scientists is to uncover them. Students of this group who selected positions E and F, used justification that was influenced by the UAE culture, 56%. Group two included students' selections of positions B and C that formed 16% of students' responses. These views were in agreement with the epistemological view that scientists invent them. The work of Ryan and Aikenhead (1992) reported a different result for the ontological view; however, they reported 40% of students held a middle viewpoint, which does not exist in this study, instead a large percentage subscribed to the culture view.

[Please insert Table (4) about here]

Paradigm vs. Coherence of Concepts across Disciplines

Freedom of scientific imagination and freedom of investigating the world and scientists' backgrounds in general form different lenses to different individuals; as a result, the same thing could have different meanings for different people. For example, gold for chemists is no more than a number of electrons circling around the nucleus; electrons in the last orbit determine gold reactions with other substances. On the other hand, for physicists the physical properties of gold are of interest, not

the number of electrons. Of course for commercial advertising gold has a completely different meaning. But what did Emirates science students think about this issue? Item 15 (91111) assessed students' views about this topic. They were asked to respond to the following statement: "Scientists in different fields look at the same thing from different points of view (for example, H^+ causes chemists to think of acidity and physicists to think of protons). This makes it difficult for scientists in different fields to understand each others' work." Results of students' responses can be classified into two groups. Group one included 56% of the sample who indicated that scientific ideas have the same meaning across all disciplines. This is consistent with the uninformed view that advocates that scientists strive to discover the absolute truth; and truth will be the same for all scientists. Group one included 12% (of the sample), which have a cultural background. Group two included 38% of the sample; they agreed that the same thing might have different meanings in different disciplines. This is in agreement with the informed view that scientists' work within a scientific community, which approves and validates their knowledge, and the ease with which knowledge is accepted is related to how close disciplines are. Of this group (23% of the sample) believed that everything God created has enough meanings to serve different purposes.

Conclusion

This study showed that Emirate high school science students' views about the epistemology of science were divided mainly into two views: the uninformed view, and the informed view. As summarized in Table (5), in some cases a high percentage of students' responses have indicated that they were holding an uninformed view, such as their view about the scientific method. Other cases have shown that students were holding an informed view, such as their view about the

nature of observation. The results suggested that students' cultural background influenced their views about the epistemology of science.

[Please insert Table (5) about here]

Students mostly selected uninformed positions in topics related to the scientific method, hypotheses, theories, and laws, and the scientific approach. By analysis of the UAE students' responses, one could draw a conclusion regarding the important issues that needed to be emphasized in the future science curriculum. Two main points were noticed. First, issues that gained a high percentage are those that are related to science as a process. UAE students' responses reflected a weakness in the UAE science curriculum. Second, the misconceptions of these items were high. A combination of the UAE response in the uninformed view and the misconception gave a gloomy picture. For example, in their response to item 6 "hypotheses, theories, and laws" 87% of the UAE students fall in these two categories.

Most students held informed views regarding the nature of scientific observation, the nature of classification schemes, and the scientific approach to investigations as well as precision and uncertainty in scientific knowledge. Analysis of these views revealed that students' cultural background has contributed in the high percentage that an informed view of science has gained. The basic fundamental beliefs in the UAE culture are that no human being can claim that he/she has reached absolute and true knowledge; only God can. UAE science educators in the last two decades unintetially distorted these basics beliefs. Science curriculum in the UAE has been emphasizing the content of science; this content was isolated from the UAE social context. In addition; scientific process was ignored; therefore, a misconception emerged when an item related to the scientific process was asked. The two different messages UAE students received might result in producing learners' skepticism about science. For example, learners who believed that only God has the

absolute truth will be very skeptical when the teacher introduces knowledge as final. Also when the teacher introduces the scientific method as the only way to gain knowledge, students will doubt it because they believe that knowledge can be acquired by other means. Badran (1988) argued that Arab thinkers are in a case where they need science but do not believe in it; they use its products but do not accept its claims. This is because the cultural views about science are in conflict with many basic beliefs, such as: knowledge is absolute, the scientific method is the only way to gain knowledge and observation is not theory-laden.

The presence of such views indicates a cultural influence on students' understandings about the nature of science. At least 21% of students selected positions that express cultural background. This is one of the most important messages this study presented to the Ministry of Education and Youth represented by curriculum designers, science educators, and science teachers. The present results are also of interest to the international science education community; it offers them evidence of the influence of culture on students' epistemology of science.

Ryan & Aikenhead (1992) argued that science educators shifted from the impersonal, scientific, and socially sterile depiction of science that is emphasized by the traditional view (uninformed view) towards the contemporary view (informed view) that is based on a history/philosophy approach. We argue here that students should be helped to view science differently. They need to use it in current events to make personal and social decisions that relate to science. This can be achieved only if the Ministry of Education and Youth would adopt a new goal for science teaching that explicitly stresses the importance of introducing the nature of science. This goal should be presented in a way that takes into consideration the formation of coherent view of science based on the Islamic view as well as the latest developments in

epistemology of science. Science educators around the world need to pay close attention to students' cultural backgrounds in order to help teach science properly.

The existence of the uninformed views about the epistemology of science in Emirates students' thinking is alarming; it affects their practices in doing science and can create what Tobin (1996) called "symbolic violence" which impedes the learning of science. This implies that curriculum designers as well as the other parties who are interested in the teaching of science could make use of this result. Presently, curriculum is designed externally, it needs to be designed internally, i.e. it should be built around the student and his culture. Religion, culture, history, society, and environment should be considered when developing science curriculum. A curriculum of a different country or society does not convey the same message. The same experience does not necessarily give the same product for different students (Driver and Bell, 1986; Osborne and Wittrock, 1983).

This effort should be accompanied by another serious effort to help science teachers themselves (who are basically trained according to the traditional view about science) to understand the new view about the nature of science. Lederman's (1997), and Palmquist and Finley (1997) agreed that both in-service and pre-service science teachers need ample experiences to ensure real understanding about the nature of science.

References

Abimbola, I. O. (1983). The relevance of the "new" philosophy of science for the science curriculum. *School Science and Mathematics.* 83(3), 181-192.

about STS Topics. *Journal of Research in Science Teaching*, 25(8), 607-29.

Aikenhead, G. & Ryan, A. (1992). Students' perceptions about the epistemology of science. *Science Education*, 76(6), 559-580.

Al-Suaidi, Y. (1980). *Al-Islam Wa Al-Ilm Al-Tagriby (Islam and Experimental Science)*. Kuwait: Al-Falah Co.

American Association for the Advancement of Science (1989). *Project 2061: Science for All Americans*. Washington, DC: Author.

Badran, E. (1988). Regarding the concept of science in the Arab *mind (Hawel Mafahin Al-Ilm fi Al-Akliah Al-Arabiah. Al-Mustakbal Al-Arabi*, 116,_19-39.

BouJaoude, S. (1996). Epistemology and Sociology of science according to Lebanese educators and students. *Paper presented at the Annual Meeting of the National Association for Research in Science Teaching*. St. Louis MO. March 31- April 3.

Bridgman, P. W. (1950). *The reflections of a physicist*. New York: Philosophical Library.

Bronowski, J. (1978). *The origin of knowledge and imagination*. New Haven, CT: Yale University Press.

Brown, H. I. (1977). *Perception, theory, and commitment: The new philosophy of science*. Chicago, IL: University of Chicago Press.

Butterfield, H. (1965). *The origin of modern science*. 1300-1800. Rev. ed. New York: Free Press.

Cleminson, A. (1990). Establishing an epistemological base for science teaching in the light of contemporary nations of the nature of science and of how children learn science. *Journal of Research in Science Teaching*, 27(5), 429-445.

Driver, R. & Bell, E. (1986). Students' thinking and learning of science: a contemporary view. *The Schools Science Review*. 67(240), 443-456.

Duschl,R. (1990). *Restructuring science education*. New York: Teachers College Press.

Einstein, A. & Infeld, L. (1938). *The evolution of physics.* Cambridge, England: Cambridge University Press.

Griffiths, A. & Barman, C. (1995). High schools' views about the nature of science: results from three countries. *School Science and Mathematics,* 95(5), 248-255.

Haidar, A. (1999). Emirates pre-service and in-service teachers views about the nature of science. *International Journal of Science Education.*

Hanson, N. (1958). *Pattern of Discovery.* Cambridge: Cambridge University Press.

Hazen, R. M., & Trefil, J. (1991). *Science matters.* New York: Doubleday.

Idris, J. (1987). The Islamization of the Sciences: Its philosophy and methodology. *The American Journal of Islamic Social Sciences,* 4, 201-208.

Hurd, P.D. (1960). *Biological education in American secondary schools,* 1890-1960. Washington, DC: AIBS.

Keller, E. F. (1983). *A feeling for the organism.* New York: W. H. Freeman.

Keller, E. F. (1985). *Reflections on science and gender.* New Haven, CT: Yale University Press.

King, B. B. (1991). Beginning teachers' knowledge of and attitudes toward history and philosophy of science. *Science Education,* 75(1), 135-141.

Kimball, M. E. (1965). *Opinion of scientists and science teachers. Unpublished master's thesis.* Stanford University, Stanford, CA.

Kimball, M.E. (1968). Understanding the nature of science: A comparison of scientists and science teachers. *Journal of Research in Science Teaching,* 2(1), 3-6.

Klopfer, L., & Cooley, W. (1961). *Test on understanding science,* From W. Princeton, NJ: Educational Testing Service.

Kuhn, T. S. (1962). *The structure of scientific revolutions.* Chicago, IL: University of Chicago Press.

Kuhn, T. S. (1970). Logic of discovery or psychology of research. In I Lakatos

& M. Musgrave, Eds., *Criticism and the growth of knowledge.* Cambridge, England, Cambridge University Press.

Lakatos, I. (1970). Falsification and methodology of science research programs. In I Lakatos & M. Musgrave, (Eds.), *Criticism and the growth of knowledge.* Cambridge, England, Cambridge University Press.

Lederman, N. (1990). Establishing an epistemological base for science teaching in the light of contemporary notions of the future of science and how children learn science. *Journal of Research in Science Teaching,* 27(5), 429-445.

Lederman, N. (1992). Students' and teachers' conceptions of the nature of science: a review of the research. *Journal of Research in Science Teaching, 29(4),* 331-359.

Lederman, N. & Niess, M. (1997). The nature of science: Naturally? *Journal of School Science and Mathematics, 97,* 1-2.

Lederman, N. G., & Zeidler, D. L. (1987). Science teachers' conceptions of the nature of science: Do they really influence teacher behavior? *Science Education,* 71(5), 721-734.

Millar, R. (1995). Knowledge and action: *Students' understanding of the procedures of scientific inquiry.* Paper presented at the First European Conference for Research in Science Education, Leeds, UK.

Ministry of Education and Youth (1997). *Statistical Yearbook. Ministry of Education and Youth.*

Munby, A. h. (1982). *What is scientific thinking?* Ottawa, Canada: Science Council of Canada Publications Office.

Nasr, S. (1987). *Traditional Islam in the Modern World.* London: Routledge & Kegan Paul.

Osborne, R. & Wittrock, M. C. (1983). Learning in science: A generative approach. *Science Education.* 67(4), 489-508.

Pomeroy, D. (1992). Science across cultures: Building bridges between traditional Western and Alaskan Native cultures. In S. Hills (Ed.), *The history and philosophy of science in science education.* Vol. 11. Kingston, Ontario: Queen's University, pp.257-268.

Pomeroy, D. (1993). Implications of teachers' beliefs about the nature of science: Comparison of the beliefs of scientists, secondary science teachers, and elementary teachers. *Science Education,* 77, 261-278.

Popper, K. (1962). *Conjectures and refutations: The growth of scientific knowledge.* New York: Harper & Row.

Popper, K. (1963). *Conjectures and refutations.* New York: Harper Torchbooks.

Popper, K. (1968). *The logic of scientific discovery.* New York: Harper &Row .

Qadir, C. (1991). *Philosophy and Science in the Islamic World.* London: Routledge.

Rayan, A. & Aikenhead, G. (1992). Students' preconceptions about the epistemology of science. *Science Education,* 76, 559-580.

Rattansi, P. (1989). History and philosophy of science multicultural science teaching. In M. Shortland and A Warwick (Eds). *Teaching the history of science.* Oxford: Basil Blackwell, pp. 118-125.

Rutherford, F. J., & Ahlgren, A. (1990). *Science for all American.* New York: Oxford University Press.

Rubba, P. A. & Anderson, O. (1978). Development of an instrument to assess secondary school students' understanding of the nature of scientific knowledge. *Science Education.* 62(4), 449-458.

Saunders, H. N. (1955). *The teaching of general science in tropical secondary schools.* London: Oxford University Press.

Tobin, K. (1996). *Cultural perspectives on the teaching and learning of science. Effect of Traditional Cosmology on Science Education Symposium,* Faculty of Education,

Ibaraki University, Sep. 23-27.

Trowbridge, L. E. & Bybee, R. W. (1986). *Becoming a secondary school science teacher.* Columbus, OH: Merrill.

Welch, W.W. (1979). Twenty years of science curriculum developments: A look back. In D. C. Berliner (Ed.), *Review of Research in education* (vol. 7,pp. 282-306). Washington DC: AERA.

Whewell, W. (1971). *On the philosophy of discovery.* New York: Burt Franklin. (Original work published 1860).

Table 1

Students' Responses to Item 1 (10112).

		Defining science is difficult because science is complex and does many things. but mainly science is:
%		Your position, basically: (Please select one)
15	A.	Finding a new useful knowledge for the good life of human being.
19	B.	Collection of all information and facts known about the world.
9	C.	Every thing we know about the world.
14	D.	Exploring the unknown using the scientific method, which leads to the establishment of theories and principles.
2	E.	Every thing known using the scientific method
5	F.	The methods used to understand and explain the natural phenomena.
34	G.	A divine thing, no human being can master (know it all), so it is difficult to define.
0	H.	I do not understand
1	I.	I do not know enough about the subject to make a choice
1	J.	Non of these choices fits my basic view point

Table 2

Students' Responses to Item 5 (90411).

Even when scientific investigations are done correctly, the knowledge that scientists discover from those investigations may change in the future		
%	Your position, basically: (please select one)	
2	A.	Scientific knowledge does not change, scientists reach them through excellent inquiries and investigations.
4	B.	As long as the scientific method has been used in an investigation, its result will not change.
4	C.	Scientific knowledge appears to change because the new investigation adds to it, but previous knowledge does not change.
12	D.	New technology may play a role in correcting old knowledge.
5	E.	Knowledge is built upon theories scientists' hold, and theories are subjected to changes.
68	F.	God said in the Holy Qur'an "You (Human Beings) have been only given little knowledge," so surly scientists' knowledge do not reach optimum. Every discovery adds to or modifies old.
2	G.	I do not understand
2	H.	I do not know enough about the subject to make a choice
1	I.	Non of these choices fits my basic view point

Table 3

Students' Responses to Item 10 (90621).

The best scientists are those who follow the steps of the scientific method.		
%	Your position, basically: (Please select one)	
20	A.	The scientific method leads to precise, accurate, and unbiased results. Thus, the best scientists follow its steps.
14	B.	The scientific method is necessary to minimize errors.
7	C.	The scientific method is the only way to get a job done successfully.
11	D.	It is not necessary to follow the scientific method, many scientific discoveries resulted by accident.
7	E.	Scientists should follow the scientific method if they want to reach correct knowledge.
7	F.	Not necessarily, a scientist may follow a creative way of his own.
7	G.	Scientists may discover thing by unscientific method such as accident.
22	H.	Knowledge can be transmitted to a human by the well of God, which the scientific knowledge has nothing to do with it.
1	I.	I do not understand
2	J.	I do not know enough about the subject to make a choice
1	K.	Non of these choices fits my basic view point

Table 4

Students' Responses to Item 14 (91013).

For this item, assume that a gold miner "discovers" gold while an artist "invents" a sculpture. Some people think that scientists discover scientific theories. Others think those scientists invent them. What do you t?

%		Your Position, Basically: (Please select one)
13	A.	Ideas are there all the time, the role of scientists is to uncover them.
7	B.	Theories unlike laws, they could be accepted by some scientists and rejected by others; therefore, they are the invention of scientists.
9	C.	Hypotheses that are made by scientists develop to theories; thus scientists invent theories.
9	D.	Scientists discover theories, but they invent the ways to obtain them.
21	E.	Theories are there in the universe. They describe the universe that God created. So scientists discover those theories; they do not invent them.
35	F.	Scientists do not create theories from nothing; they are hidden in the universe; God utilizes scientists to uncovering them.
2	G.	I do not understand
2	H.	I do not know enough about the subject to make a choice
2	I.	Non of these choices fits my basic view point

Table 5

Summary of Students' Responses to Questionnaire Items.

Item	Topic	Uninformed	Informed	Misconceptions	Others
1	Definition of science	49	15	34	2
2	Nature of observation	9	86	-	5
3	Nature of models	21	59	17	3
4	Classification schemes	16	80	-	4
5	Tentativeness of knowledge	10	85	-	5
6	Hypotheses theories and laws	55	5	32	8
7	Role of assumptions	29	48	18	5
8	Scientific equations	24	19	48	9
9	Scientific method	70	25	-	5
10	Scientific method	48	29	19	4
11	Scientific approach to	60	14	22	4
12	Investigations	16	79	-	5
13	Precision and uncertainty	16	78	-	6
14	Epistemology	78	16	-	6
15	Paradigm vs. coherence of concepts	56	38	-	6
	Average	37	45	13	5

SE063918

U.S. Department of Education
Office of Educational Research and Improvement (OERI)
[Image] [Image]
National Library of Education (NLE)
Educational Resources Information Center (ERIC)

Reproduction Release
(Specific Document)

I. DOCUMENT IDENTIFICATION:

Title: United Arab Emirates Students Views about the Epistemology of Science

Author(s): Abdullateef Haidar & Nagib M. Balfakih
Corporate Source: Publication Date: 1999

II. REPRODUCTION RELEASE:

In order to disseminate as widely as possible timely and significant materials of interest to the educational community, documents announced in the monthly abstract journal of the ERIC system, Resources in Education (RIE), are usually made available to users in microfiche, reproduced paper copy, and electronic media, and sold through the ERIC Document Reproduction Service (EDRS). Credit is given to the source of each document, and, if reproduction release is granted, one of the following notices is affixed to the document.

If permission is granted to reproduce and disseminate the identified document, please CHECK ONE of the following three options and sign in the indicated space following.

The sample sticker shown below will be affixed to all Level 1 documents	The sample sticker shown below will be affixed to all Level 2A documents	The sample sticker shown below will be affixed to all Level 2B documents
[Image]	[Image]	[Image]
Level 1	Level 2A	Level 2B
[Image]	[Image]	[Image]
Check here for Level 1 release, permitting reproduction and dissemination in microfiche or other ERIC archival media (e.g. electronic) and paper copy.	Check here for Level 2A release, permitting reproduction and dissemination in microfiche and in electronic media for ERIC archival collection subscribers only	Check here for Level 2B release, permitting reproduction and dissemination in microfiche only

Documents will be processed as indicated provided reproduction quality permits.
If permission to reproduce is granted, but no box is checked, documents will be processed at Level 1.

I hereby grant to the Educational Resources Information Center (ERIC) nonexclusive permission to reproduce and disseminate this document as indicated above. Reproduction from the ERIC microfiche, or electronic media by persons other than ERIC employees and its system contractors requires permission from the copyright holder. Exception is made for non-profit reproduction by libraries and other service agencies to satisfy information needs of educators in response to discrete inquiries.

Signature: Abdullateef Haidar Printed Name/Position/Title: Abdullateef Haidar
Organization/Address: United Arab Emirates University Telephone: +971504488931
Fax: +97137518588
E-mail Address: A.Haidar@uaeu.ac.ae Date:

III. DOCUMENT AVAILABILITY INFORMATION (FROM NON-ERIC SOURCE):

If permission to reproduce is not granted to ERIC, or, if you wish ERIC to cite the availability of the document from another source, please provide the following information regarding the availability of the document. (ERIC will not announce a document unless it is publicly available, and a dependable source can be specified. Contributors should also be aware that ERIC selection criteria are significantly more stringent for documents that cannot be made available through EDRS.)

Publisher/Distributor:

Address:

Price:

IV. REFERRAL OF ERIC TO COPYRIGHT/REPRODUCTION RIGHTS HOLDER:

If the right to grant this reproduction release is held by someone other than the addressee, please provide the appropriate name and address:

Name:

Address:

V. WHERE TO SEND THIS FORM:

Send this form to the following ERIC Clearinghouse:

However, if solicited by the ERIC Facility, or if making an unsolicited contribution to ERIC, return this form (and the document being contributed) to:

ERIC Processing and Reference Facility
1100 West Street, 2nd Floor
Laurel, Maryland 20707-3598
Telephone: 301-497-4080
Toll Free: 800-799-3742
FAX: 301-953-0263
e-mail: ericfac@inet.ed.gov
WWW: http://ericfac.piccard.csc.com